DOCUMENT RESUME

ED 056 489 EM 009 345

| | |
|---|---|
| AUTHOR | Ricketson, D. Schley; And Others |
| TITLE | Implementation of Systems Engineering Concepts in Army Training. |
| INSTITUTION | Human Resources Research Organization, Alexandria, Va. |
| SPONS AGENCY | Office of the Chief of Research and Development (Army), Washington, D.C. |
| REPORT NO | PP-11-71 |
| PUB DATE | Jun 71 |
| NOTE | 15p.; Paper presented at the Institute of Electrical and Electronics Engineers Symposium on Man-Machine Systems (Winter Park, Florida, November 1970) |
| EDRS PRICE | MF-$0.65 HC-$3.29 |
| DESCRIPTORS | *Curriculum Design; *Job Analysis; *Military Training; *Systems Approach; Training Techniques |

ABSTRACT

A review of systems engineering concepts as applied to training programs at Army training schools was conducted. It was concluded that through systems engineering, the programs are being reoriented toward actual job requirements, reducing the "nice-to-know" and focusing on the "need-to-know." Since the programs are being constructed by personnel relatively unskilled in systems engineering and training program design, appropriate training methods are recommended. An Army-developed systems engineering guide was reviewed and reduced to outline form, and a graphic isplay of products of information and sub-products, or elements of work, was prepared. (Author)

ED056489

Professional Paper 11-71

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY

HumRRO

# Implementation of Systems Engineering Concepts in Army Training

D. Schley Ricketson, Robert H. Wright, and Russel E. Schulz

**HUMAN RESOURCES RESEARCH ORGANIZATION**
300 North Washington Street • Alexandria, Virginia 22314

Presentation at
Institute of Electrical and Electronics Engineers
Symposium on Man-Machine Systems
Winter Park, Florida November 1970

EM009345

June 1971

Prepared for

Office of the Chief of Research and Development
Department of the Army
Washington, D.C. 20310

1

The Human Resources Research Organization (HumRRO) is a nonprofit corporation established in 1969 to conduct research in the field of training and education. It is a continuation of The George Washington University Human Resources Research Office. HumRRO's general purpose is to improve human performance, particularly in organizational settings, through behavioral and social science research, development, and consultation. HumRRO's mission in work performed under contract with the Department of the Army is to conduct research in the fields of training, motivation and leadership.

The contents of this paper are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.



Published
June 1971
by
HUMAN RESOURCES RESEARCH ORGANIZATION
300 North Washington Street
Alexandria, Virginia 22314

| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| Professional Paper 11-71 | | |

| 4. Title and Subtitle | 5. Report Date |
|---|---|
| Implementation of Systems Engineering Concepts in Army Training | June 1971 |
| | 6. Performing Organization Code |
| 7. Author(s)<br>D. Schley Ricketson, Robert H. Wright, and Russel E. Schulz | 8. Performing Organization Report No.<br>PP 11-71 |
| 9. Performing Organization Name and Address<br>Human Resources Research Organization (HumRRO)<br>300 North Washington Street<br>Alexandria, Virginia 22314 | 10. Work Unit No. |
| | 11. Contract or Grant No.<br>DAHC 19-70-C-0012 |
| 12. Sponsoring Agency Name and Address<br>Office, Chief of Research and Development<br>Department of the Army<br>Washington, D.C. 20310 | 13. Type of Report and Period Covered |
| | 14. Sponsoring Agency Code |

15. Supplementary Notes HumRRO Division No. 6 (Aviation), Fort Rucker, Alabama; paper presented at the Eleventh Institute of Electrical and Electronics Engineers Symposium on Man-Machine Systems, November 1970, in Winter Park, Florida.

16. Abstract

This paper is an account of a HumRRO review of systems engineering concepts as applied to training programs at an Army training school. It was concluded that through systems engineering, the programs are being reoriented toward actual job requirements, reducing the "nice-to-know" and focusing on the "need-to-know." Since the programs are being constructed by personnel relatively unskilled in systems engineering and training program design, appropriate training methods are being recommended. An Army-developed systems engineering guide (CONARC Regulation 350-100-1, *Systems Engineering of Training*) was reviewed and reduced to outline form, and a graphic display of products of information and sub-products, or elements of work, was prepared.

17. Key Words
Army Training
Curriculum Design
Job Analysis
Job Requirements
Systems Engineering

18. Distribution Statement
Approved for public release; distribution unlimited.

| 19. Security Classif. (of this report) | 20. Security Classif. (of this page) | 21. No. of Pages | 22. Price |
|---|---|---|---|
| Unclassified | Unclassified | 13 | |

## Prefatory Note

The research reported in this paper was performed by the Human Resources Research Organization, Division No. 6 (Aviation), Fort Rucker, Alabama, as a technical advisory service. The paper was presented by Dr. Wright at the Eleventh Institute of Electrical and Electronics Engineers (IEEE) Symposium on Man-Machine Systems, November 1970, in Winter Park, Florida.

# IMPLEMENTATION OF SYSTEMS ENGINEERING CONCEPTS IN ARMY TRAINING

D. Schley Ricketson, Robert H. Wright, and
Russel E. Schulz

In the past, Army training programs have been developed by experienced job holders using methods that were largely intuitive. Over time, the programs were modified by training or administrative personnel when changes seemed desirable. Therefore, the content of training programs has consisted of information the developers logically thought trainees should have. As an example, experimental studies suggest that excessive amounts of time are often devoted to instructing maintenance trainees in the theories of power plant operation, electricity, and hydraulics. On the other hand, little systematic effort was devoted to determining the potential contribution of each training point to practical performance of the job in the field.

In February 1968, a large scale effort was initiated in the Army to systems engineer all training programs within a five-year period. The purpose is to design courses of instruction to focus on those skills and knowledges essential for adequate performance of jobs at the entry level. The approach is to have experienced Army job holders systematically design training programs against actual job requirements by using the following processes in sequence:

(1) Job analysis
(2) Selection of tasks for school training
(3) Training analysis
(4) Development of training materials
(5) Development of testing materials

(and, following the administration of training)

(6) Quality control and feedback

Based on an analysis of actual job requirements, such a systematic design of training programs can be expected to eliminate most of the "nice-to-know" content that characterizes some portions of today's training. It should also better orient training programs to those essential "need-to-know" skills and knowledges required to perform jobs at the field entry level.

Army job holders in this program are not highly experienced or knowledgeable in systems engineering methods, training program design, or state-of-the-art training technology. However, they are given an orientation to systems engineering and are provided an Army-developed systems engineering guide (CONARC Regulation 350-100-1, *Systems Engineering of Training—Course Design*). Education specialists at each participating training school are assigned to provide assistance and technical supervision to working level personnel.

Approximately one year after its inception, a review of the systems engineering program was undertaken at one of the Army training schools by members of the HumRRO staff. The goals of that review effort were to examine the implementation of the program and to provide suggestions for changes that might improve its effectiveness. In this paper we will present the findings of that review and their implications for the use of systems engineering concepts in large scale training programs.

## METHOD

A sequential analysis approach was used in the review. This approach included interviews with systems engineering personnel about the program's operation and an analytical follow-up of the leads derived from these interviews. The follow-up consisted of detailed analyses of the Army's systems engineering guide to determine what deficiencies existed from the user's point of view. It was also hoped that the analyses would lead to suggestions for improvements that might reduce or eliminate problems the users had in implementing the systems engineering concept.

Interviews with administrative-level personnel were conducted to obtain information concerning the program's organization, administrative policies, and procedures of implementation. Working-level personnel were then interviewed regarding day-to-day mechanics of the program.

The interviews showed that several features of the systems engineering guide appear to be sources of difficulty in its implementation. Analyses were then undertaken to determine how the guide, or manual, could best be changed to improve implementation of the program with the type of personnel available.

Initial review indicated that a number of the steps necessary for systems engineering were obscured in the text of the manual. In order to gain a more precise view of the training systems engineering process, it was found necessary to reduce the manual to outline form with emphasis on identifying each step required. The two types of steps identified were classified as products and subproducts. *Products* were defined as major units of documented information, and *subproducts* as elements of work resulting in documented information required to complete a product.

The products and subproducts were then arranged in a block flow diagram (Figure 1). Subproducts (light outlined boxes) flow from left to right, ending with the completed product. Products (dark outlined boxes) flow from top to bottom. This graphic outline provides an overview that was not available in the manual, of the extensive amount of documentation required for systems engineering of training. Instead of the six apparently uncomplicated processes mentioned, there are, in fact, a total of 100 items produced—19 major products that comprise 81 subproducts.

One of the most frequent comments voiced during the interviews concerned the difficulty experienced in trying to produce units of work in a form that would allow the information contained to be used satisfactorily in the completion of downstream work. In several instances, large units of work had to be completely redocumented because the information was in a form that could not be used.

In order to clarify the relationships between units of work in the systems engineering process, the required links of information between the products and subproducts shown in Figure 1 were determined. These links were then divided into inputs and outputs. As used here, an *input* consists of information from other products and subproducts that is required to complete a given product or subproduct. An *output* is information contained in a product or subproduct that is required to complete other products or subproducts.

The inputs and outputs for some of the products and subproducts in the training systems engineering process are shown in Figure 2. For the user, there is a clear advantage in knowing what inputs and outputs are required for a given product or subproduct. He knows what products and subproducts contain the information needed to complete the product or subproduct being worked on. The user should also have a good idea about the form in which he must complete the product or subproduct because he can identify the requirements that downstream products and subproducts impose on this information. He can then prepare the information so its form is in accord with downstream requirements.

## Product/Subproduct Block Flow Diagram

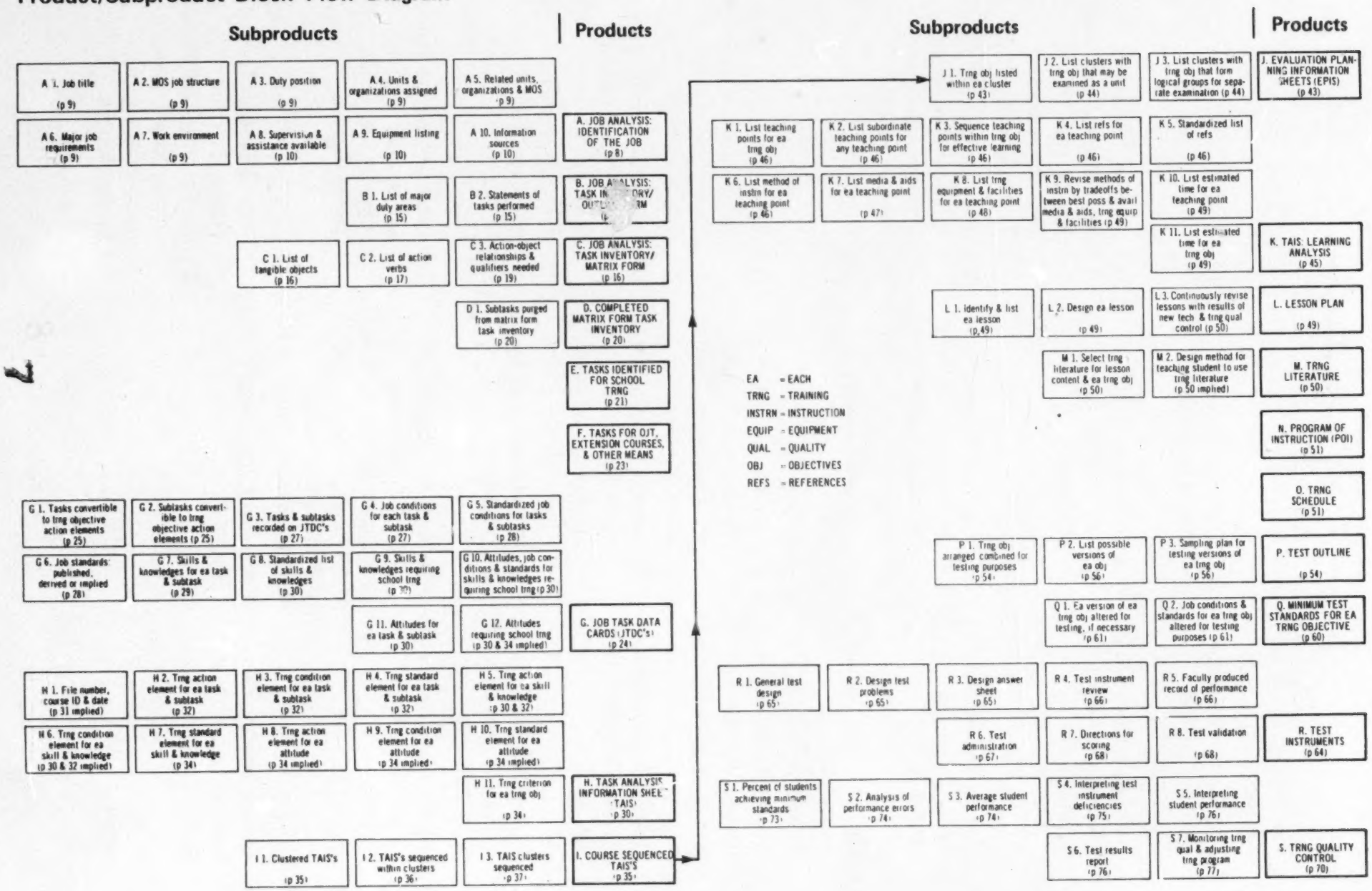
Subproducts
Products
A 1. Job title (p 9)
A 2. MOS job structure (p 9)
A 3. Duty position (p 9)
A 4. Units & organizations assigned (p 9)
A 5. Related units, organizations & MOS (p 9)
A 6. Major job requirements (p 9)
A 7. Work environment (p 9)
A 8. Supervision & assistance available (p 10)
A 9. Equipment listing (p 10)
A 10. Information sources (p 10)
A. JOB ANALYSIS: IDENTIFICATION OF THE JOB (p 8)
B 1. List of major duty areas (p 15)
B 2. Statements of tasks performed (p 15)
B. JOB ANALYSIS: TASK INVENTORY/ OUTLINE FORM (p
C 1. List of tangible objects (p 16)
C 2. List of action verbs (p 17)
C 3. Action-object relationships & qualifiers needed (p 19)
C. JOB ANALYSIS: TASK INVENTORY/ MATRIX FORM (p 16)
D 1. Subtasks purged from matrix form task inventory (p 20)
D. COMPLETED MATRIX FORM TASK INVENTORY (p 20)
E. TASKS IDENTIFIED FOR SCHOOL TRNG (p 21)
F. TASKS FOR OJT, EXTENSION COURSES, & OTHER MEANS (p 23)
G 1. Tasks convertible to trng objective action elements (p 25)
G 2. Subtasks convertible to trng objective action elements (p 25)
G 3. Tasks & subtasks recorded on JTDC's (p 27)
G 4. Job conditions for each task & subtask (p 27)
G 5. Standardized job conditions for tasks & subtasks (p 28)
G 6. Job standards published, derived or implied (p 28)
G 7. Skills & knowledges for ea task & subtask (p 29)
G 8. Standardized list of skills & knowledges (p 30)
G 9. Skills & knowledges requiring school trng (p 30)
G 10. Attitudes, job conditions & standards for skills & knowledges requiring school trng (p 30)
G 11. Attitudes for ea task & subtask (p 30)
G 12. Attitudes requiring school trng (p 30 & 34 implied)
G. JOB TASK DATA CARDS (JTDC's) (p 24)
H 1. File number, course ID & date (p 31 implied)
H 2. Trng action element for ea task & subtask (p 32)
H 3. Trng condition element for ea task & subtask (p 32)
H 4. Trng standard element for ea task & subtask (p 32)
H 5. Trng action element for ea skill & knowledge (p 30 & 32)
H 6. Trng condition element for ea skill & knowledge (p 30 & 32 implied)
H 7. Trng standard element for ea skill & knowledge (p 34)
H 8. Trng action element for ea attitude (p 34 implied)
H 9. Trng condition element for ea attitude (p 34 implied)
H 10. Trng standard element for ea attitude (p 34 implied)
H 11. Trng criterion for ea trng obj (p 34)
H. TASK ANALYSIS INFORMATION SHEET (TAIS) (p 30)
I 1. Clustered TAIS's (p 35)
I 2. TAIS's sequenced within clusters (p 36)
I 3. TAIS clusters sequenced (p 37)
I. COURSE SEQUENCED TAIS'S (p 35)
Subproducts
Products
J 1. Trng obj listed within ea cluster (p 43)
J 2. List clusters with trng obj that may be examined as a unit (p 44)
J 3. List clusters with trng obj that form logical groups for separate examination (p 44)
J. EVALUATION PLANNING INFORMATION SHEETS (EPIS) (p 43)
K 1. List teaching points for ea trng obj (p 46)
K 2. List subordinate teaching points for any teaching point (p 46)
K 3. Sequence teaching points within trng obj for effective learning (p 46)
K 4. List refs for ea teaching point (p 46)
K 5. Standardized list of refs (p 46)
K 6. List method of instrn for ea teaching point (p 46)
K 7. List media & aids for ea teaching point (p 47)
K 8. List trng equipment & facilities for ea teaching point (p 48)
K 9. Revise methods of instrn by tradeoffs between best poss & avail media & aids, trng equip & facilities (p 49)
K 10. List estimated time for ea teaching point (p 49)
K 11. List estimated time for ea trng obj (p 49)
K. TAIS: LEARNING ANALYSIS (p 45)
L 1. Identify & list ea lesson (p 49)
L 2. Design ea lesson (p 49)
L 3. Continuously revise lessons with results of new tech & trng qual control (p 50)
L. LESSON PLAN (p 49)
M 1. Select trng literature for lesson content & ea trng obj (p 50)
M 2. Design method for teaching student to use trng literature (p 50 implied)
M. TRNG LITERATURE (p 50)
N. PROGRAM OF INSTRUCTION (POI) (p 51)
O. TRNG SCHEDULE (p 51)
P 1. Trng obj arranged combined for testing purposes (p 54)
P 2. List possible versions of ea obj (p 56)
P 3. Sampling plan for testing versions of ea trng obj (p 56)
P. TEST OUTLINE (p 54)
Q 1. Ea version of ea trng obj altered for testing, if necessary (p 61)
Q 2. Job conditions & standards for ea trng obj altered for testing purposes (p 61)
Q. MINIMUM TEST STANDARDS FOR EA TRNG OBJECTIVE (p 60)
R 1. General test design (p 65)
R 2. Design test problems (p 65)
R 3. Design answer sheet (p 65)
R 4. Test instrument review (p 66)
R 5. Faculty produced record of performance (p 66)
R 6. Test administration (p 67)
R 7. Directions for scoring (p 68)
R 8. Test validation (p 68)
R. TEST INSTRUMENTS (p 64)
S 1. Percent of students achieving minimum standards (p 73)
S 2. Analysis of performance errors (p 74)
S 3. Average student performance (p 74)
S 4. Interpreting test instrument deficiencies (p 75)
S 5. Interpreting student performance (p 76)
S 6. Test results report (p 76)
S 7. Monitoring trng qual & adjusting trng program (p 77)
S. TRNG QUALITY CONTROL (p 70)
EA = EACH
TRNG = TRAINING
INSTRN = INSTRUCTION
EQUIP = EQUIPMENT
QUAL = QUALITY
OBJ = OBJECTIVES
REFS = REFERENCES

Figure 1

**Part of the Input/Output Outline Form Analysis**

| Product and Subproduct | Inputs | Outputs |
|---|---|---|
| H 1. File Number, Course ID, and Date (p 31) | A 1. Job Title | Not Identified |
| H 2. Training Action Element for Each Task and Subtask (p 32) | G 3. Tasks and Subtasks Recorded on JTDCs | H 11. Training Criterion for Each Training Objective |
| H 3. Training Condition Element for Each Task and Subtask (p 32) | G 5. Standardized Job Conditions for Tasks and Subtasks | I 1. Clustered TAISs<br>Q 2. Job Conditions and Standards for Each Training Objective Altered for Testing Purposes |
| H 4. Training Standard Element for Each Task and Subtask (p 32) | A 6. Major Job Requirements<br>G 6. Job Standards: Published, Derived or Implied | Q 2. Job Conditions and Standards for Each Training Objective Altered for Testing Purposes |
| H 5. Training Action Element for Each Skill and Knowledge (p 30 & 32) | G 9. Skills and Knowledges Requiring School Training | I 1. Clustered TAISs |
| H 6. Training Condition Element for Each Skill and Knowledge (p 30 & 32, Implied) | G 10. Attitudes, Job Conditions and Standards for Skills and Knowledges Requiring School Training | Q 2. Job Conditions and Standards for Each Training Objective Altered for Testing Purposes |
| H 7. Training Standard Element for Each Skill and Knowledge (p 34) | G 10. Attitudes, Job Conditions and Standards for Skills and Knowledges Requiring School Training | Q 2. Job Conditions and Standards for Each Training Objective Altered for Testing Purposes |
| H 8. Training Action Element for Each Attitude (p 34, Implied) | G 12. Attitudes Requiring School Training | I 1. Clustered TAISs |
| H 9. Training Condition Element for Each Attitude (p 34, Implied) | A 6. Major Job Requirements<br>A 7. Work Environment<br>A 8. Supervision and Assistance Available<br>A 9. Equipment Listing<br>A 10. Information Sources | Q 2. Job Conditions and Standards for Each Training Objective Altered for Testing Purposes |
| H 10. Training Standard Element for Each Attitude (p 34, Implied) | A 10. Information Sources | H 11. Training Criterion for Each Training Objective<br>Q 2. Job Conditions and Standards for Each Training Objective Altered for Testing Purposes |

Figure 2 8

**Input/Output Matrix Form Analysis**

Products and Subproducts (Dots Indicate Required Inputs)

Products and Subproducts (Dots Indicate Required Outputs)

A 1. Job Title (p 9)
A 2. MOS Job Structure (p 9)
A 3. Duty Position (p 9)
A 4. Units & Organizations Assigned (p 9)
A 5. Related Units, Organizations & MOS (p 9)
A 6. Major Job Requirements (p 9)
A 7. Work Environment (p 9)
A 8. Supervision & Assistance Available (p 10)
A 9. Equipment Listing (p 10)
A10. Information Sources (p 10)
A Job Analysis Identification

R 7. Directions for Scoring (p 68)
R 8. Test Validation (p 68)
R Test Instruments (p 64)
S 1. Percent of Students Achieving Minimum Standards (p 73)
S 2. Analysis of Performance Errors (p 74)
S 3. Average Student Performance (p 74)
S 4. Interpreting Test Instrument Deficiencies (p 75)
S 5. Interpreting Student Performance (p 76)
S 6. Test Results Report (p 76)
S 7. Monitoring Trng. Quality & Adjusting Trng. Program (p 77)
S Training Quality Control (p 70)

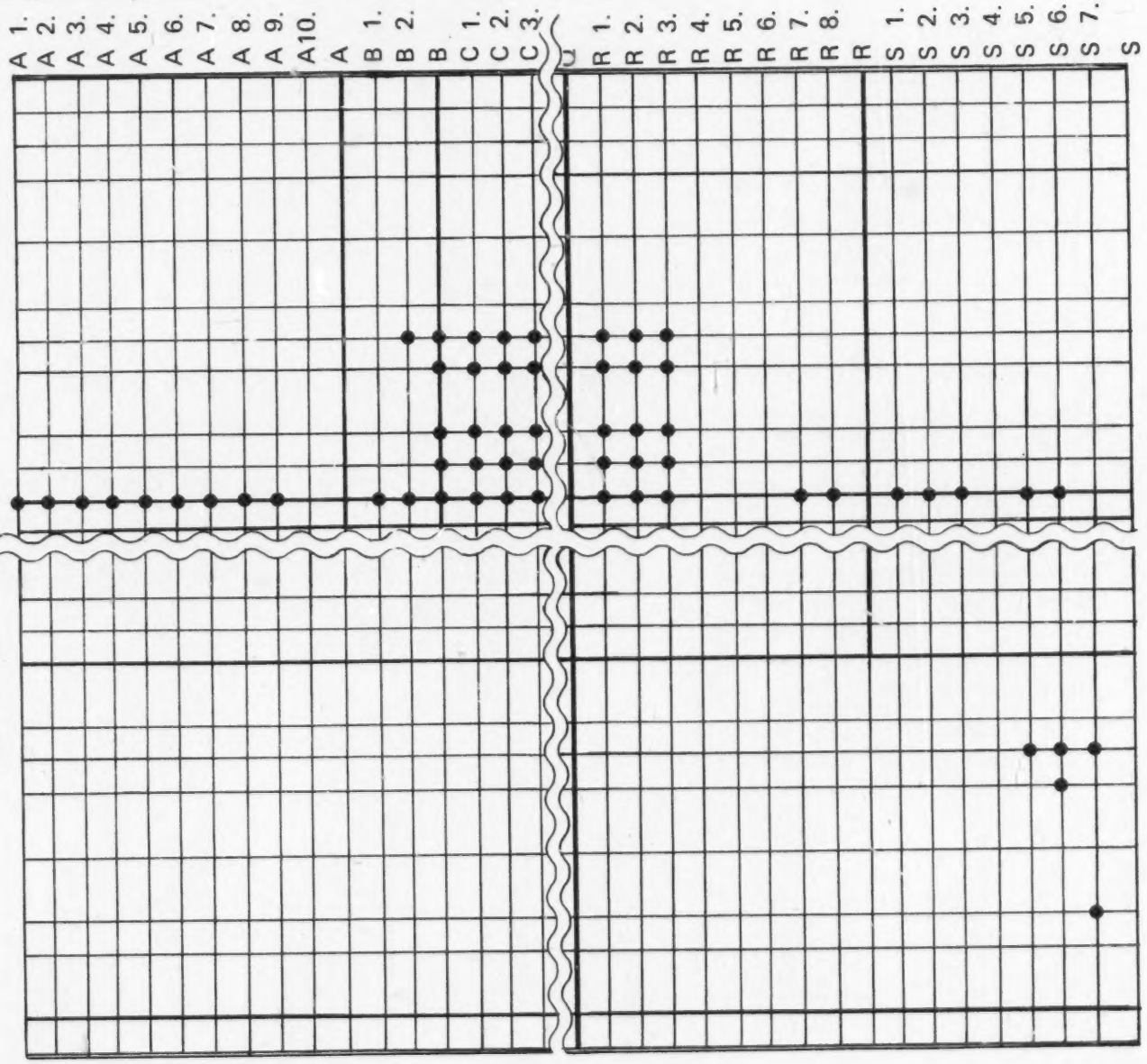


Figure 3

## Analysis of Content Factors

| CONARC REG 350-100-1 CONTENT EVALUATION FACTORS / PRODUCTS/ SUBPRODUCTS | Does CON REG 350-100-1 Clearly Identify This Product/Subproduct as an Essential Step? | Is Sufficiently Detailed Procedural Guidance Provided? | Are Practical and Specific Working Definitions of Terms Provided? | Are Requirements Other Products/ Subproducts Impose on This Product/Subproduct Clearly Identified? | Is the Use of Examples Satisfactory? | Are Reference Materials, Job Aids, or Other Information Sources Cited? | CON REG 350-100-1 Specifies No CDG Personnel Experience Requirements. | Experience Needed to Prepare This Product/Subproduct? | CON REG 350-100-1 Specifies No CDG Personnel Skills & Knowledges Required | Skills and Knowledges Needed. |
|---|---|---|---|---|---|---|---|---|---|---|
| A. Job Analysis: Identification of the Job (p 8) | Yes | No | No | No | Clarify | Need More | | Field | | Field Tasks |
| A 1. Job Title (p 9) | Yes | Yes | Yes | None | Yes | Specify | | None | | None |
| A 2. MOS Job Structure (p 9) | Yes | Yes | Yes | None | No | Need More | | None | | None |
| A 3. Duty Position (p 9) | Yes | Yes | Yes | None | Yes | Sufficient | | None | | None |
| A 4. Units and Organizations Assigned (p 9) | Yes | Yes | Yes | None | No | Sufficient | | None | | None |
| A 5. Related Units, Organizations and MOS (p 9) | Yes | Yes | Yes | None | No | Need More | | Field | | Field Tasks |
| A 6. Major Job Requirements (p 9) | Yes | No | No | No | No | Need More | | Field | | Field Tasks |
| A 7. Work Environment (p 9) | Yes | Yes | Yes | No | No | Need More | | Field | | Field Tasks |
| A 8. Supervision and Assistance Available (p 10) | Yes | No | Yes | No | No | Specify | | Field | | None |
| A 9. Equipment Listing (p 10) | Yes | Yes | Yes | No | No | Sufficient | | Field | | Field Tasks |
| A10. Information Sources (p 10) | Yes | Yes | Yes | No | Yes | Need More | | Field | | Field Tasks |
| B. Job Analysis: Task Inventory/ Outline Form (p 15) | Yes | No | No | No | More Range | Specify | | Field | | Field Tasks |
| B 1. List of Major Duty Areas (p 15) | Yes | No | No | No | Yes | Specify | | Field | | Field Tasks |
| B 2. Statements of Tasks Performed (p 15) | Yes | No | No | No | Yes | Specify | | Field | | Field Tasks |
| C. Job Analysis: Task Inventory/ Matrix Form (p 16) | Yes | Yes | No | No | More Range | Sufficient | | Field | | Field Tasks |
| C 1. List of Tangible Objects (p 16) | Yes | Yes | No | No | More Range | Sufficient | | Field | | Field Tasks |
| C 2. List of Action Verbs (p 17) | Yes | Yes | No | No | More Range | Sufficient | | Field | | Field Tasks |
| C 3. Action-Object Relationships and Qualifiers Needed (p 19) | Yes | Yes | No | No | More Range | Specify | | Field | | Field Tasks |
| D. Completed Matrix Form Task Inventory (p 20) | Yes | No | Yes | No | More Range | No | | Field | | Field Tasks |
| D 1. Subtasks Purged From Matrix Form Task Inventory (p 20) | No | No | Yes | No | None Prov[a] | No | | Field | | Field Tasks |
| E. Tasks Identified for School Training (p 21) | Yes | No | Yes | No | None Prov | No | | Field, Platform & Flight Instn. | | Field Tasks, MOI |
| F. Tasks for OJT, Extension Courses, & Other Means (p 23) | No | No | Yes | No | None Prov | No | | Field, Platform & Flight Instn. | | Field Tasks, MOI |

[a]Prov Provided.

Figure 4

To provide the user with a global view of these information requirements, the inputs and outputs of each product and subproduct were arranged in matrix form. Figure 3 shows a sectioned part of this matrix with inputs on the vertical axis and outputs on the horizontal axis. Inputs required by a product/subproduct are located by tracing down to each dot and then left to the product/subproduct containing the information. Products/subproducts requiring outputs are located by tracing right to each dot and then upward to the product/subproduct needing the information. This matrix enables the user to determine at a glance all the information requirements of a product or subproduct.

Next, an attempt was made to compare the manual's content against the factors considered as major sources of difficulty to the user in implementing it. Eight factors, identified in the interviews and previous analyses, were used to evaluate each product and subproduct as treated in the manual. A portion of the evaluation is shown in Figure 4. Products and subproducts are listed on the left and the evaluation factors across the top. Each of these factors is considered important to the satisfactory completion of products and subproducts by users who are relatively unskilled in training technology or program design. This analysis codified results of the interviews and previous analyses. It provides a summary of those aspects of the manual that require improvement.

## FINDINGS FROM THE HumRRO REVIEW

### Program

(1) The content of training programs is being changed and improved through systems engineering. The programs are being reoriented toward actual job requirements, reducing the "nice-to-know" and focusing on the "need-to-know."

(2) The programs are being constructed by personnel relatively unskilled in systems engineering and training program design. Consequently, the training methods being recommended tend to be the methods with which the working level personnel themselves were trained. Also, current advancements in training technology appear to be only minimally reflected in the systems-engineered programs.

### Personnel

(1) The Army job holders charged with implementing the program are not highly experienced in systems engineering methods, training program design, or state-of-the-art training technology.

(2) They do receive an orientation to systems engineering and are provided program guidance by an education specialist. However, a break-in period ranging from weeks to months is necessary before a new worker can contribute effectively to the systems engineering effort.

(3) The manual cites no personnel experience or skills and knowledges required to satisfactorily complete each product and subproduct in the process, although many products and subproducts require different types and levels of expertise. There is also no single handbook or set of references on current training technology that is practical for use by Army job holder personnel who perform systems engineering.

(4) There are not, nor are there likely to be, sufficient numbers of well-qualified specialists to make the training technology decisions required. Therefore, the use of current training technology in systems-engineered training programs may be expected to be less than is desirable. Until a practical handbook of training technology can be developed, a detailed orientation to systems engineering and as much daily guidance as possible should be provided by training technology experts.

### Manual: Procedural Guidance

(1) Procedural guidance provided in the manual is basically oriented to experienced *training* personnel. The six apparently uncomplicated systems engineering processes around which the manual is organized are global concepts. Army users are not given a full understanding of what each concept is and how it should be implemented.

(2) The terminology, examples, and reference material provided in the manual are not adequate for full understanding and practical application by working level personnel.

(3) To experienced training researchers, the manual seems satisfactory on first reading. However, with subsequent readings it becomes more apparent that the typical user will have difficulty in implementing training systems engineering from the standpoint of *what he is supposed to do* and *just exactly how he is supposed to do it.*

### Manual: Units of Work

(1) Many of the smaller units of work required for the training systems engineering program are obscured in the manual. Some of these products and subproducts are not clearly identified as required steps. They are buried in the manual's text or are presented at an outline level that is the same as items that are not products or subproducts. As a consequence, uncertainty exists as to exactly what should be done with them.

(2) Not all necessary steps are specifically identified, and no overview of the process is available. Analysis of the manual resulted in the identification of the units of work required. A surprisingly large amount of documentation, 19 major products and 81 subproducts, was identified in the analysis, showing the systems engineering of training process to be much more complex and demanding than might be anticipated from initial review of the manual.

### Manual: Information Requirements

(1) During the interviews it was frequently commented that units of work had to be completely revised because they did not meet downstream requirements. It appeared that large amounts of time and effort were being wasted because the interdependencies between upstream and downstream work were not fully recognized.

(2) Since a full understanding of information requirements appears essential to satisfactory completion, of many products and subproducts, these requirements were identified for each product and subproduct. A large and complex flow of input/output information between products and subproducts was shown in the matrix analyses (Figures 2 and 3).

### Manual: Content Factors

(1) Eight factors were developed from results of the interviews and analyses as being responsible for the major difficulties encountered in implementing the systems engineering of training program.

(2) Each product and subproduct required by the manual was evaluated against each of the eight content factors as to whether it could be satisfactorily completed by personnel relatively unskilled in systems engineering methods or training technology. The analysis showed that the manual was deficient in one or more of the eight factors for all products and subproducts.

## CONCLUSIONS

The progress made in the Army's systems engineering of training program represents a promising start toward the development of optimized training programs. Much of the

"nice-to-know" information commonly found in training programs is being omitted in favor of that which the trainee "needs-to-know." The identification of current on-the-job requirements and subsequent realignment of training programs with them will represent a major achievement when obtained on an Army-wide basis. The program has made progress with respect to the training technology introduced, and several avenues exist for future improvements.

The type of personnel available for systems engineering training programs should receive major consideration in the approach to and administration of a program. The manual adopted by the Army was oriented toward the *training* specialist rather than the *job* specialist. The necessity to rely primarily on job specialists to perform systems engineering with this manual was a major source of complications. The job specialist was found to require very detailed procedural guidance if a training specialist was not available on an almost continual basis.

A great deal of experience should be represented on any team that is systems engineering a training program. Experience on the job, in platform and practical exercise instruction, in training administration, in systems engineering, and in training technology should all be represented or at least available. However, unless large numbers of training experts suddenly become available, teams of relatively unskilled Army personnel must perform systems engineering. They must be provided manuals, job aids, and handbooks that will promote the maximum practical implementation of systems engineering concepts and current developments in training technology.

It is not enough simply to change the content of a training program. Systems engineering should also result in training methods that have been reviewed and improved, based on the latest developments in training technology. Unfortunately, training design handbooks now in use are neither abreast of current developments nor designed for use by persons other than training experts. At present, one of the clearest needs of Army training schools is a training technology handbook written so that it can be understood and applied by Army personnel.

Regarding the systems engineering manual, the primary problem experienced by Army users was that they did not know just what to do or specifically how to go about doing it. In order for the manual to provide clearer and more specific guidance for its Army users, information obtained from the interviews and analyses was used to develop a suggested new outline format (Figure 5).

Figure 6 presents an explanation of each item in this new format. The products and subproducts in each section of the manual should be clearly identified as an essential step in the systems engineering process. In each section, the objective, general procedure, and scope should be identified and carefully explained to show the user what work is to be done, why it is done, and the context in which it is to be done. Under each subproduct, all information required to satisfactorily complete that subproduct should be systematically documented. Items 4.a.1 through 4.a.9 were developed from the content factor analysis (Figure 4) to provide this information in a form that would be meaningful for administrative and working level personnel. For instance, the analysis showed that the manual specified no personnel experience or skills and knowledges required for the optimal completion of any product or subproduct. Item 4.a.2 seeks to correct this omission by requiring the manual to identify and explain the reasons for any special experience or skills and knowledges needed by the user to successfully complete the subproduct.

This new outline for the manual provides a standardized format for each section, product, and subproduct with clearly identified requirements for their completion. It also specifically points out the essential information required by relatively unskilled working level personnel to complete the systems engineering process. Finally, this format is

responsive to the most common suggestion made in the interviews: that the systems engineering manual should itself be systems engineered.

Initial feedback received from systems engineering personnel indicates that the information presented in the flow diagrams, matrices, and outlines of this review should be of immediate assistance to personnel performing systems engineering and of long-term aid to those preparing revisions to the manual. The general procedures developed, while intended for military training, are equally applicable in other training contexts.

## Suggested Outline of a New Format for the Systems Engineering Manual

I. SECTION NAME

1. Objective of section
2. General procedure
3. Scope of section
4. Product A. Name of first product in section
   - 4.a Subproduct A 1. Name of first subproduct in section
     - 4.a.1 Definition of terms
     - 4.a.2 Experience or expertise required
     - 4.a.3 Required inputs
     - 4.a.4 Procedure
     - 4.a.5 Required outputs
     - 4.a.6 Subproduct performance standard
     - 4.a.7 Examples
     - 4.a.8 References
     - 4.a.9 Review, approval, or validation
   - 4.b Subproduct B 1. Name of second subproduct in section

   - 4.n Subproduct A n. Name of last subproduct in section
5. Product B. Name of second product in section

n. Product n. Name of last product in section

Figure 5

## Explanation of New Format Items for the Systems Engineering Manual

I. SECTION NAME

1. *Objective of section.* The objective of this section should clearly state not only the definition of the section, but also reasons for the section and the specific use for information from the section.

2. *General procedure.* The general procedural steps (products) required to complete the section should be identified, defined, and their interrelationships explained. The dependency of each product on the other should be clearly evident.

3. *Scope of section.* The scope should describe any boundaries or limitations on the procedures for completion and intent of the section. The user should be clearly aware of exactly how the products and subproducts are to be utilized in the systems engineering process.

4. *Product A. Name of each product in section.* Each product should be fully and specifically defined along with statements of general procedural guidelines, any particular user expertise or skills and knowledges required, the use for which the product's information is intended and any suggested review, validation, or approval of the product.

4.a *Subproduct A 1. Name of each subproduct in section.* Each subproduct required to complete the product should be clearly identified and explained.

4.a.1 *Definition of terms.* All terms employed that are not considered part of the user's repertoire should be listed and defined in a manner that is meaningful to the user and practical for completion of the subproduct.

4.a.2 *Experience or expertise required.* Identify and explain the reasons for any special experience or skills and knowledges required of the user to successfully complete the subproduct.

4.a.3 *Required inputs.* List each product/subproduct containing information required by the user to optimally complete this subproduct. With the listing of each product/subproduct, those items of information specifically required as inputs should be indicated.

4.a.4 *Procedure.* In a step-by-step manner, list the detailed procedures required to complete the subproduct. Such specific step-by-step guidance is essential to obtaining subproducts that are standardized across different types of jobs.

4.a.5 *Required outputs.* Each piece of output information should be listed, and can be easily determined in most cases by examination of other products/subproducts requiring inputs from this subproduct.

4.a.6 *Subproduct performance standard.* The basic standard of performance required in producing each subproduct is to comply fully with the information requirements in subsequent use or application of the outputs. To assure this, the content, scope, quality, nature, and level of detail required in subsequent uses or application of each output item need to be determined and clearly defined.

4.a.7 *Examples.* Examples should be provided that clearly illustrate the completed subproduct and/or any specific procedural step. These examples should be easily applicable to a wide range of jobs and tasks.

4.a.8 *References.* Cite both generally and specifically relevant reference materials from the bibliography that aid completion of the subproduct or any of its procedural steps. These citations should include reference to specific chapters, sections, pages, or paragraphs.

4.a.9 *Review, approval, or validation.* Define, give the reasons for, and provide procedures for any suggested review, approval, or validation of completed subproduct steps, the draft subproduct, or the completed subproduct.



Figure 6